imall

Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from, Europe, America and south Asia, supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of "Quality Parts, Customers Priority, Honest Operation, and Considerate Service", our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip, ALPS, ROHM, Xilinx, Pulse, ON, Everlight and Freescale. Main products comprise IC, Modules, Potentiometer, IC Socket, Relay, Connector. Our parts cover such applications as commercial, industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!



Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832 Email & Skype: info@chipsmall.com Web: www.chipsmall.com Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China





Freescale Semiconductor User's Guide

Document Number: MAG3110UG Rev. 2, 08/2011



RD4247MAG3110 Sensor **Toolbox Tilt-Compensated** eCompass Kit User's Guide

Introduction 1

The RD4247MAG3110 sensor toolbox tilt-compensated eCompass kit provides hardware and software for demonstrating the capability of the MAG3110 3-axis digital magnetometer in an eCompass application with hard- and soft-iron calibration.

The kit includes the following:

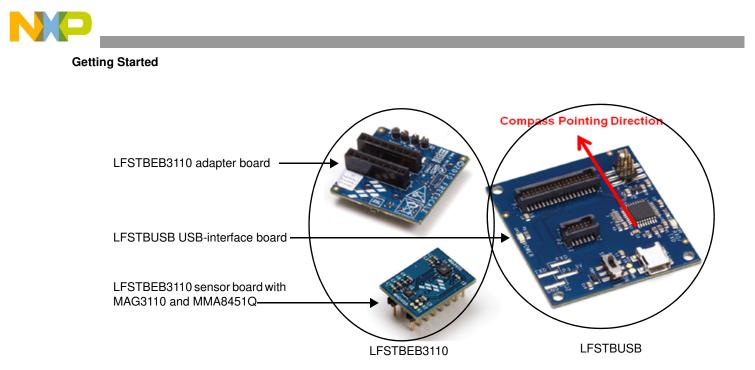
- The LFSTBUSB USB-interface board and USB cable for connecting the evaluation board to a PC's **USB** port
- The LFSTBEB3110 kit comprising the MAG3110 magnetometer and MMA8451Q accelerometer sensor board and the adapter board
- The LFSTBEB3110 Quick Start Guide

The complete kit, shown in the following illustration, is available for order under part number RD4247MAG3110.

Contents

1	Introduction
2	Getting Started
	2.1 Assembling the Kit
	2.2 Installing the Sensor Toolbox Software
	2.3 Launching the Sensor Toolbox Software 6
3	Quick-Start Demonstration7
4	Advanced eCompass Features
	4.1 Configuration Screen
	4.2 Calibration Save
	4.3 Data Log 19
5	3D Pointer Screen
6	Navigation Screen





2 Getting Started

To begin using the kit, assemble the kit's hardware and install the sensor toolbox software on the Windows[®] PC to which the kit will be connected.

2.1 Assembling the Kit

As instructed in the LFSTBEB3110 Quick Start Guide:

- 1. Attach the two LFSTBEB3110 boards to the LFSTBUSB USB-interface board.
- 2. The two LFSTBEB3110 boards are supplied connected. If they become separated, reconnect them, aligning the Pin-1 white arrows on both boards.

The hardware assembly will be completed as part of the software-installation procedure that follows.

When the kit is assembled, its compass-pointing direction is indicated by the red arrow in the preceding illustration. This direction ergonomically facilitates the evaluation of the eCompass functionality as the board assembly can be held by its USB connector.

2.2 Installing the Sensor Toolbox Software

The free sensor toolbox software provides an eCompass application with hard- and soft-iron calibration algorithms.

At the end of the installation process, you will be asked about installing a Future Technology Devices International (FTDI) serial-to-USB communications driver. This driver is required for communication between the PC and the evaluation board. If you have previously installed the sensor toolbox software, this driver already is installed.

The kit's navigation application uses a Google Maps[™] demonstration powered by the Adobe[®] Shockwave[®] software. If the free Shockwave software is not installed on your PC, follow the instructions at the end of the procedure.

NP

To install the toolbox software:

1. Download the sensor toolbox software by clicking the following link: http://www.freescale.com/sensortoolbox.

The webpage, shown below, appears.



which enrich designs with a broad range of capabilities in detecting real-world conditions, such as motion, touch or pressure.

Download Software Required for all Sensor Toolbox boards

- Click the Download Software button.
 The Sensor Toolbox Installer license agreement page appears.
- 3. Scroll down to the bottom of the page, shown below, and click the I Accept button.

SEVERABILITY. If any provision of this Agreement is held for any reason to be invalid or unenforceable, then the remaining provisions of this Agreement will be unimpaired and, unless a modification or replacement of the invalid or unenforceable provision is further held to deprive you or Freescale of a material benefit, in which case the Agreement will immediately terminate, the invalid or unenforceable provision will be replaced with a provision that is valid and enforceable and that comes closest to the intention underlying the invalid or unenforceable provision.

NO WAIVER. The waiver by Freescale of any breach of any provision of this Agreement will not operate or be construed as a waiver of any other or a subsequent breach of the same or a different provision.



- 4. Save the software's installation executable file (SensorToolboxInstaller.exe) to your PC.
- 5. Complete the kit's hardware assembly by using the supplied USB cable to connect the LFSTBUSB USB-interface board to a USB port on your PC.

If the evaluation board's red power LED does not illuminate, check the power switch located next to the board's USB connector.

6. Locate the software toolkit's installation file on your PC and double-click on it.



Getting Started

7. Proceed through the setup wizard's series of dialog boxes.

During the process, you will be asked if you want a Sensor Toolbox icon added to your Start menu and desktop.

8. When the Ready to Install dialog box, shown below, appears, review the installation configuration and click the Install button.

ady to Install	
Setup is now ready to begin installing	ng Sensor Toolbox on your computer.
Click Install to continue with the ins	tallation, or click Back if you want to review or
change any settings.	
Destination location: C:\Program Files\Freescale\Se	ensor Toolbox
Start Menu folder:	
Sensor Toolbox	
Additional tasks: Additional icons:	
Create a desktop icon	
30	

A progress bar displays the status of the software installation and the final dialog box, shown below, appears.

🐻 Setup - Sensor Toolbox	
	Completing the Sensor Toolbox Setup Wizard
	Setup has finished installing Sensor Toolbox on your computer. The application may be launched by selecting the installed icons.
	Click Finish to exit Setup.
	Install FTDI Driver
	☑ Run SensorToolbox
	Einish



- 9. Do any of the following and click the Finish button:
 - To install the Future Technology Devices International (FTDI) serial-to-USB communications driver, enable the Install FTDI Driver checkbox
 - To launch the toolbox software upon completion of the setup, leave the Run Sensor Toolbox checkbox enabled

If you chose to install the FTDI driver, a command-line window briefly appears.

10. If you do not have the Adobe Shockwave software installed on your PC, use the following link to download and install that application:

http://get.adobe.com/shockwave/

The application is now ready for use. If you left the Run Sensor Toolbox checkbox enabled, the application launches and detects the devices connected to the evaluation board. (See the next section.)



Getting Started

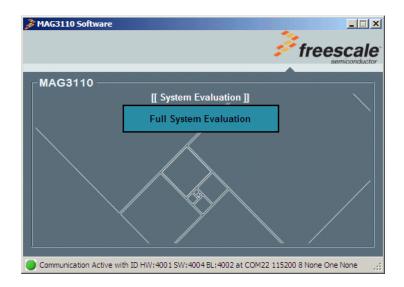
2.3 Launching the Sensor Toolbox Software

- 1. Ensure that the compass boards are connected to a USB port on your PC with the USB cable. The evaluation board's red power LED illuminates. (If the LED does not illuminate, check the power switch located next to the board's USB connector.)
- 2. Launch the toolbox software by doing either of the following:
 - Double-click on the application's desktop icon
 - Select Start > Programs > Sensor Toolbox > Sensor Toolbox

The sensor toolbox's hardware-detection dialog box, shown below, displays.



Then the MAG3110 evaluation software's main menu, shown in the following figure, displays.



3. Open the tilt-compensated eCompass application by clicking on Full System Evaluation.

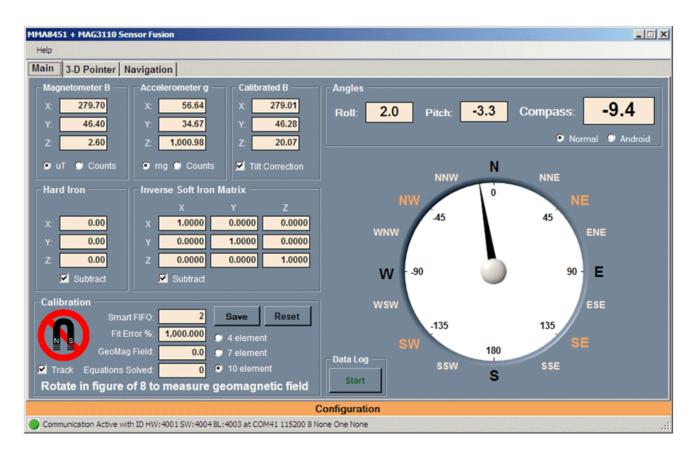


3 Quick-Start Demonstration

The following demonstration procedure familiarizes you with the Main and Configuration screens and the calibration functionality.

1. Launch the sensor toolbox software by using the procedure in Section 2.3, "Launching the Sensor Toolbox Software," on page 6.

The main eCompass screen appears with a red magnet warning icon in the Calibration frame, indicating that the compass is out of calibration. Text at the bottom of the frame advises *Rotate in figure of 8 to measure geomagnetic field*.



2. Rotate the device in a figure-eight motion as advised.

When a minimum of 16 magnetic measurements are stored in the Smart FIFO, the compass software uses those measurements to calibrate the device. The default, 10-element calibration is composed of:

- Three elements in the Hard Iron frame
- Six elements in the Inverse Soft Iron Matrix frame (There are not nine elements because the matrix is symmetrical.)
- The geomagnetic field strength in the Calibration frame



Quick-Start Demonstration

When the device is successfully calibrated, as shown in the following figure, the Calibrated frame displays:

- A Fit Error % that should be less than 2%
- Five green bars, where the red-magnet icon had appeared
- The message *Calibrated*, at the bottom of the frame



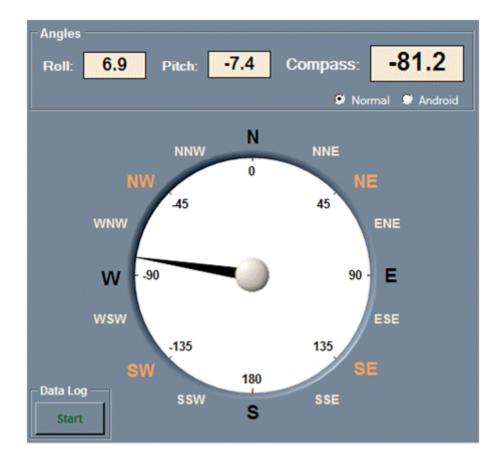
- 3. Take one of the following actions with the established calibration:
 - To freeze the current calibration, clear the Track checkbox
 - To update the calibration continuously, enable the Track checkbox
- 4. Review the readings in the Magnetometer B, Accelerometer g, and Calibrated B frames, shown in the following figure, that are located in the top, left corner of the Main screen.



- The Magnetometer B frame shows the three components of the magnetic field in μ T measured by the magnetometer sensor
- The Accelerometer g frame shows the three components of the accelerometer sensor output measured in mg
- The Calibrated B frame shows the magnetometer output corrected by the magnetic calibration and corrected for the tilt of the evaluation board



- 5. If desired, modify the display of the fields in those frames by doing any of the following:
 - To switch the magnetometer's display of the magnetic field from the default of μT to bit counts, select the Counts option
 - To switch the accelerometer's display from the default of mg to bit counts, select the Counts option
- 6. Review the Angles frame of the Main screen, shown in the following figure.



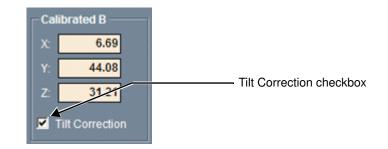
- The computed Roll, Pitch and Compass angles and displayed in degrees at the top of the frame
- The Compass angle also is displayed graphically
- The Normal and Android option buttons implement the default and Android standards for calculating roll and pitch angles
- 7. Return to the Hard Iron and Inverse Soft Iron Matrix frames in the middle, left portion of the Main screen and do the following to demonstrate the importance of an accurate magnetic calibration:



Quick-Start Demonstration

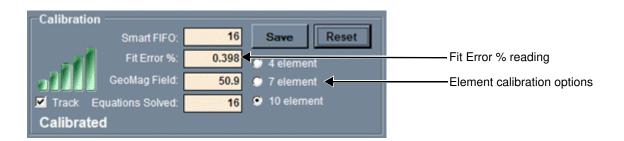
_ Hard Iron ———	_ Inverse Soft Iron	Matrix		
	x	Y	Z	
x: 259.55	x 0.9406	-0.0304	0.0055	
Y: 39.75	Y -0,0304	0.9434	0.0233	Subtract checkboxes
Z: -36.61	Z 0.0055	0.0233	1.1287	
Subtract	Subtract			

- Deselect the Subtract checkboxes in both frames to turn off the hard-iron and soft-iron corrections for the eCompass and observe how the compass heading becomes jammed.
- Select both Subtract checkboxes to reactivate the calibration corrections and watch the eCompass become unjammed again.
- 8. Demonstrate the importance of tilt-compensation algorithms by returning to the Calibrated B frame, near the top, center of the Main screen, and deselecting the Tilt Correction checkbox to turn off tilt correction for the eCompass.



The eCompass will still operate if it is held flat, but pitching or rolling the device will cause dramatic compass heading errors.

9. Examine calibration options by doing the following in the Calibration frame in the bottom, left of the Main screen:



— Sequentially select the 10 element, 7 element, and 4 element option buttons.



 Observe how the Fit Error % field's values increases, in going from the 10-element model to the 4-element model, as a less-complete calibration model is used.

The 7-element model simplifies the inverse soft-iron matrix to a diagonal matrix with zero off-diagonal elements. The calibration parameters are the three hard-iron coefficients, the three soft-iron matrix coefficients, and the geomagnetic field strength.

The 4-element model further simplifies the inverse soft iron matrix simplifies to a unit matrix. The calibration parameters are the three hard-iron coefficients and the geomagnetic field strength.

- 10. Deliberately jam the eCompass by bringing it close to a spurious magnetic field (such as a notebook hard disc or a magnet from a desktop-telephone speaker).
 - The Fit Error % field's value increases and the number of green calibration bars drops from four to one and are replaced by the red magnetic warning icon, as shown in the following figure.
 - The frame's status field displays Jammed. Rotate to re-measure geomagnetic field.

Calibratio	on ————						
	Smart FIFO:	69	Save	Reset			
	Fit Error %:	18.418	🥥 4 eleme	nt			
U	GeoMag Field:	1,434.0	🜻 7 eleme	nt			
Track	Equations Solved:	64	오 10 elem	ent			
Jammed. Rotate to re-measure geomagnetic field							

- 11. To unjam the eCompass, do either of the following:
 - Move the eCompass away from the jamming source and rotate the evaluation board to obtain new measurements of the geomagnetic field for calibration.

The Fit Error % value decreases and the number of green bars increases up to five, as the jammed calibration measurements are replaced by newer measurements.

 Click the Reset button to immediately discard all calibrations and rotate the evaluation board to capture new calibration data.



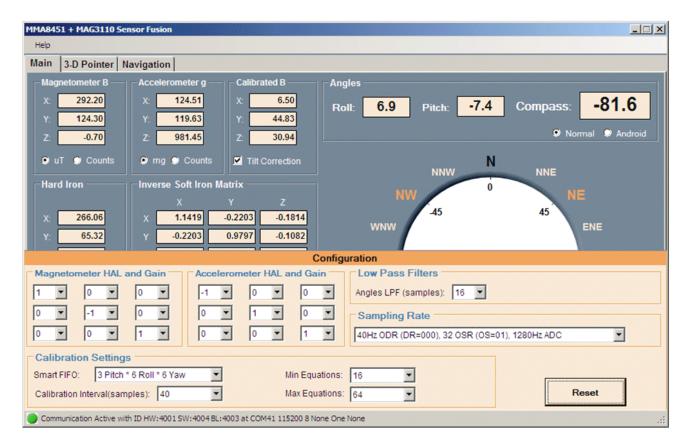
Advanced eCompass Features

4 Advanced eCompass Features

This section looks at advanced configuration and calibration features.

4.1 Configuration Screen

The Calibration screen enables advanced users to change run-time parameters. To display the screen, move the mouse pointer over the Configuration bar at the bottom of the Main screen.



The screen's features are explained in the following table.





Screen frame					
	Description				
Aagnetometer Magnetometer HAL ¹ and Gain n	and z axes of the evalu of 90 degrees. Permit 1. The magnetometer eCompass algorithms multiplying the raw m		These Hardware Abstraction Layer settings should be changed only if the sensor toolbox software is being		
Accelerometer 1 HAL ¹ and Gain n	and z axes of the evalu of 90 degrees. Permit 1. The accelerometer eCompass algorithms multiplying the raw m	s is obtained by	used with a customer evaluation board whose sensor package orientation does not match that of the MAG3110 and MMA8451Q daughter board.		
Low-Pass Filters	The Angles LPF (samples) list-box field sets the 1/e time constant (in samples) of the single-pole, exponential low-pass filters acting on the roll, pitch, and compass heading angles. The default setting is 16 samples which equates to 0.4s 1/e convergence at the default, 40-Hz sampling frequency.				
Sampling Rate T	Selects the magnetometer's output data rates and over-sampling ratios. The default rate is 40 Hz. For more details on these settings, see the <i>MAG3110 3-Axis</i> , <i>Digital</i> <i>Magnetometer Data Sheet</i> (MAG3110).				
E	Enables configuration of four parameters used for magnetic calibration.				
	Smart FIFO	Configures the data structure that calibrates the device by storing measurements of the geomagnetic field at different orientations. The default setting is 3x Pitch times 6x Roll times 6x Yaw ranges to give a total of 108 entries. The alternative setting is 4x Pitch times 8x Roll times 8x Yaw values for a total of 256 entries.			
C	Calibration Interval	Selects whether the calibration algorithms execute every 10, 20, 40, 80, 120, or 160 samples. At the default sampling rate of 40 Hz, this corresponds to a calibration every 0.25, 0.5, 1, 2, 3, or 4 seconds.			
Calibration Settings	Min Equations	Defines the minimum number of measurements stored in the Smart FIFO to be used for calibration. The default setting is 16 measurements with the alternatives of 10, 12, and 14. The lowest setting is 10 because it is impossible for the 10-element calibration model to be solved when fewer than 10 measurement equations are available.			
	Max Equations	used for calibration. The default setting is 64, measurements are bette consumption. If this field is set to 128, 1	umber of measurements stored in the Smart FIFO to be , but this can be set as high as 256. Generally, more r, but at the expense of increased processing and power 92 or 256, the Smart FIFO field should be set to its larger er value contains only 108 entries which limits umber.		
		Resets the Configuration screen settings to default values.			

Table 1 Configuration Frame



Advanced eCompass Features

¹ HAL: Hardware Abstraction Layer

To observe the effects of your calibrations, roll the mouse off of the Configuration frame to close it and display all of the Main screen. Look at the Calibration frame in the bottom, left corner of the screen.

Calibration	1			
	Smart FIFO:	48	Save	Reset
	Fit Error %:	1.540	💭 4 eleme	nt
	GeoMag Field:	54.0	💭 7 eleme	nt
Track E	quations Solved:	48	🖲 10 elem	ent
Calibrate	d			

- The Smart FIFO value shows the number of measurements currently stored in the Smart FIFO.
- The Equations Solved value shows the number of measurements equations currently being used for the solution.
- The Equations Solved value will remain at zero until the Min Equations measurements (set in the Configuration screen's Calibration frame) are available for use. The value then will jump to the Min Equations setting and increase up to the value set for Max Equations.

4.2 Calibration Save

The Calibration frame's Save button enables advanced users to analyze and visualize the magnetic calibration by saving the calibration to a tab-delimited ASCII text file that can be opened with a text or spreadsheet application.

When the button is clicked, a Save As dialog box, shown in the following figure, prompts the user a filename and storage location for the calibration file.



Save As					? ×
Save in:	Calibrations		•	G 🦸 🖻 🖽•	
My Recent Documents Desktop My Documents My Computer B07217 on B	E Calibration 1.tx	t			
My Network	File <u>n</u> ame:	Calibration2		•	<u>S</u> ave
Places	Save as type:	All files (*.*)		_	Cancel

A sample calibration file follows, with inserted annotations displayed in italic text.

The Smart FIFO has dimensions 3x6x6 for 108 entries in total.

Total assigned smart FIFO size	108
FIFO Roll Phi dimension	6
FIFO Pitch Theta dimension	3
FIFO Yaw Psi dimension	6

The calibration has been computed for the 10 element model.

Number of calibration parameters 10

The hard-iron calibration vector in μT *.*

Hard	iron	Vx	(uT)	260.3826
Hard	iron	Vy	(uT)	41.64858
Hard	iron	Vz	(uT)	-52.42494

The inverse soft-iron matrix.

<pre>Inverse Soft Iron invW[0][]</pre>	0.9679827	-0.03510316	0.004310295
Inverse Soft Iron invW[1][]	-0.03510318	1.015078	0.03668828
Inverse Soft Iron invW[2][]	0.004310329	0.03668828	1.020367

The ellipsoid fit matrix equal to the square of the inverse soft-iron matrix.

Ellipsoid matrix A[0][]	0.9382414	-0.06945354	0.007282599
Ellipsoid matrix A[1][]	-0.06945354	1.032962	0.07452545
Ellipsoid matrix A[2][]	0.007282599	0.07452545	1.042513

Advanced eCompass Features

The fitted geomagnetic field strength in μT . Geomagnetic field B (uT) 52.31701

The calibration Fit Error in %.

Calibration fit error % 0.7030118

The number of measurement equations used for this calibration.

Measurements used in solution

The sample number index of the earliest magnetometer reading used for the calibration.

Earliest sample index used

The number of measurements stored in the Smart FIFO.

Smart FIFO count

49

49

-1

The actual magnetometer measurements stored in the Smart FIFO.

Sample :	index	Bpx (uT)	Bpy (uT)	Bpz (uT)
	80	304.5	16.9	-37.6
	13	245.7	-6.4	-33.8
	92	298.3	15.5	-73.2
	93	300.2	13.6	-66
	78	299	21	-23.1
	68	219.9	42.1	-17.9



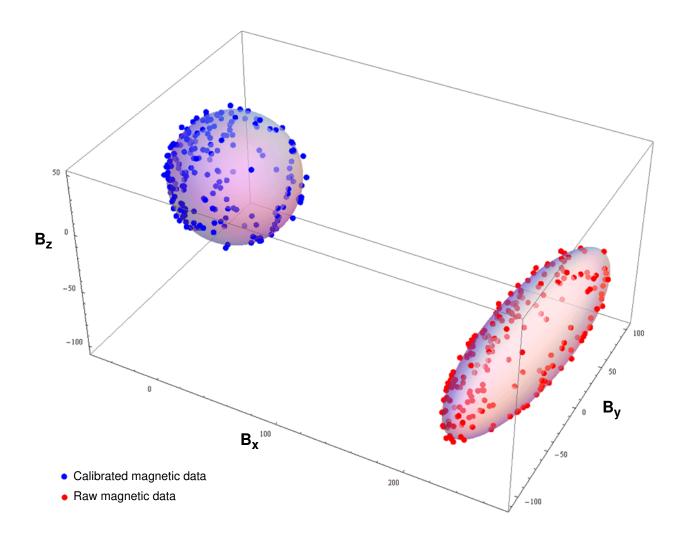
The text after this line can be pasted into Wolfram Mathematica to display the raw and calibrated data:

```
Mathematica visualization script
rawdata={
\{304.5, 16.9, -37.6\},\
\{245.7, -6.4, -33.8\},\
{298.3,15.5,-73.2},
{300.2,13.6,-66},
. . .
\{219.9, 42.1, -17.9\}\}
caldata={
{43.63754,-26.1265,14.40905},
{-12.44556, -47.57435, 17.17816},
{37.53175, -28.63608, -21.9941},
\{39.46864, -30.36727, -14.70897\},\
. . .
{-39.05349,3.145957,35.07017}}
plot1 = ListPointPlot3D[rawdata, AxesLabel -> {Bx, By, Bz}, Axes -> True, BaseStyle -> {FontSize
-> 14}, BoxRatios -> Automatic, PlotStyle -> Directive[Red, PointSize[0.02]]]
a={{0.9382414,-0.06945354,0.007282599}},
\{-0.06945354, 1.032962, 0.07452545\},
\{0.007282599, 0.07452545, 1.042513\}\}
plot2=RegionPlot3D[{x-(260.3826),y-(41.64858),z-(-52.42494)}.a.
{x-(260.3826),y-(41.64858),z-(-52.42494)}<2737.07,
{x,260.3826-120,260.3826+120}, {y,41.64858-120,41.64858+120},
\{z, -52.42494 - 120, -52.42494 + 120\},\
PlotPoints -> 100, Mesh -> None, AxesLabel -> {Bx, By, Bz}, BaseStyle -> {FontSize -> 14},
AxesLabel -> Automatic, PlotStyle -> Opacity[0.5]]
plot3 = ListPointPlot3D[caldata, AxesLabel -> {Bx, By, Bz}, Axes -> True, BaseStyle -> {FontSize
-> 14}, BoxRatios -> Automatic, PlotStyle -> Directive[Blue, PointSize[0.02]]]
plot4=RegionPlot3D[x*x+y*y+z*z<2737.07, {x,-100,100}, {y,-100,100}, {z,-100,100},
PlotPoints -> 100, Mesh -> None, AxesLabel -> {Bx, By, Bz}, BaseStyle -> {FontSize -> 14},
AxesLabel -> Automatic, PlotStyle -> Opacity[0.5]]
Show[plot1, plot2, PlotRange -> Automatic]
Show[plot3, plot4, PlotRange -> Automatic]
Show[plot2, plot4, PlotRange -> Automatic]
Show[plot1, plot2, plot3, plot4, PlotRange -> Automatic]
```



Advanced eCompass Features

A typical mathematical plot is shown in the following figure. The raw magnetic data is shown in red and shows strong hard- and soft-iron distortions. The calibrated magnetic data is shown in blue and lies on the surface of a sphere, centered at the origin.

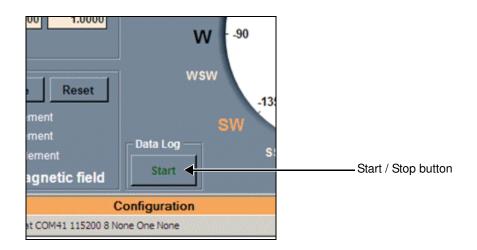






4.3 Data Log

The Data Log frame, in the bottom center of the Main screen contains a Start / Stop button, as shown in the following figure. That button enables or disables, respectively, the logging of sensor data to a file on the PC's hard disc.



When the Start button is clicked, the user is prompted for the output filename and location. Because the file is written in the ASCII format, a .txt filename extension should be used. The data is written at a fixed rate of 10 Hz, irrespective of the sampling rate selected for the eCompass.

The file format is below. The column headings after Time Stamp match the data fields in the main screen.

The columns and example data are as follows:

Time when this line was recorded and written.

Time 09/08/2011 10:40

Sample number incrementing every 1/40s for the default, 40-Hz sample rate.

38151

Sample index

The x, y and z raw magnetic field values in μT .

Врх	(uT)	290.2
Вру	(uT)	57.9
Bpz	(uT)	-6.8

The x, y and z raw accelerometer values in mg.

Gpx	(mg)	123.54
Gpy	(mg)	111.82
Gpz	(mg)	987.31

The calibrated and tilt-compensated magnetometer readings.

Врх	(comp,	uT)	23.22
Вру	(comp,	uT)	6.78
Bpz	(comp,	uT)	48.6



3D Pointer Screen

The pitch, roll and yaw/Compass angles in degrees.

Roll (deg)		6.5
Pitch (deg)		-7.1
Yaw Compass	(deg)	-15.7

5 3D Pointer Screen

IMA8451 + MAG3110 Sensor	iusion V2.2			freescal
Main 3-D Pointer Navig	ation			•
- 3D-Pointer status	3-D Pointer OFF			
Screen width:		w origin:	53.400 9.290	
X sensitivity: Y sensitivity:	0.125 Yaw de	eviation:	-12.360 -0.670	
Mouse X: Mouse Y:	541	Start/Stop		(lerm
	403			
	W:4001 SW:4004 BL:4002 at COM2	Configu		

The 3D Pointer screen uses the sensor daughter board to control of the PC mouse pointer. First ensure that the compass is calibrated. To start the demonstration, click the Start/Stop button. The compass (yaw) and pitch angles are used to position the mouse pointer horizontally and vertically, respectively.

To stop the demonstration, manipulate the sensor daughter board to position the mouse pointer over the Start/Stop button and click the PC mouse.



Navigation Screen

6 Navigation Screen



The Navigation screen uses all three angles output from the sensor daughter board to control the Google Maps display. The roll angle controls the display in the left and right direction. The pitch angle controls the display in forward and backward direction. The compass/yaw angle controls the rotation of the map display.

The PC must be connected to the internet for this demonstration and the Adobe Shockwave software must be installed. If Adobe Shockwave is not installed, please follow the instructions at:

http://get.adobe.com/shockwave/



How to Reach Us:

Home Page: www.freescale.com

Web Support: http://www.freescale.com/support

USA/Europe or Locations Not Listed: Freescale Semiconductor, Inc. Technical Information Center, EL516 2100 East Elliot Road Tempe, Arizona 85284 1-800-521-6274 or +1-480-768-2130 www.freescale.com/support

Europe, Middle East, and Africa: Freescale Halbleiter Deutschland GmbH Technical Information Center Schatzbogen 7 81829 Muenchen, Germany +44 1296 380 456 (English) +46 8 52200080 (English) +49 89 92103 559 (German) +33 1 69 35 48 48 (French) www.freescale.com/support

Japan: Freescale Semiconductor Japan Ltd. Headquarters ARCO Tower 15F 1-8-1, Shimo-Meguro, Meguro-ku, Tokyo 153-0064 Japan 0120 191014 or +81 3 5437 9125 support.japan@freescale.com

Asia/Pacific: Freescale Semiconductor China Ltd. Exchange Building 23F No. 118 Jianguo Road Chaoyang District Beijing 100022 China +86 10 5879 8000 support.asia@freescale.com

For Literature Requests Only: Freescale Semiconductor Literature Distribution Center 1-800-441-2447 or +1-303-675-2140 Fax: +1-303-675-2150 LDCForFreescaleSemiconductor@hibbertgroup.com

MAG3110UG Rev. 2 08/2011 Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals", must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.

Freescale and the Freescale logo are trademarks of Freescale Semiconductor, Inc., Reg. U.S. Pat. & Tm. Off. Xtrinsic is a trademark of Freescale Semiconductor, Inc.

All other product or service names are the property of their respective owners.

© 2011 Freescale Semiconductor, Inc. All rights reserved.

RoHS-compliant and/or Pb-free versions of Freescale products have the functionality and electrical characteristics as their non-RoHS-compliant and/or non-Pb-free counterparts. For further information, see http://www.freescale.com or contact your Freescale sales representative.

For information on Freescale's Environmental Products program, go to http://www.freescale.com/epp.

